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SUBMICROMETER PARTICLE FORMATION AND MERCURY SPECIATION UNDER O_2-CO_2 COAL COMBUSTION

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Oxy-coal combustion represents a promising technology for mitigating CO_2 in the atmosphere. Many effects and advantages resulting from this system on combustion by-products have been demonstrated. Nonetheless, the effects of O_2-CO_2 coal combustion on flame stability, particle formation and mercury speciation are not well understood. In this study, a CFD model is employed to examine the effects of O_2-CO_2 combustion on temperature profiles, flame stability and the formation of combustion by-products in a turbulent combustor. The results are compared with those obtained under conventional combustion conditions (air). In addition, combustion of coal in an oxygen-carbon dioxide system was studied in a drop tube reactor to compare the resultant aerosol characteristics of submicrometer-sized particles and mercury speciation to air-coal (conventional) combustion. For aerosol characteristics, the experiments were conducted at different mixing ratios of O_2/CO_2 and $O_2/N_2/CO_2$. The results show that when replacing all the N_2 in air by CO_2, the geometric mean size (d_{pg}) of the submicrometer particles is smaller (approximately 28%) with less associated mass than that formed with air. The geometric mean size (d_{pg}) of the submicrometer particles increases from 29 nm to 54 nm when the O_2/CO_2 mixing ratio is increased from 1:4 to 4:4. At a fixed concentration of O_2, the geometric mean size (d_{pg}) of the submicrometer particles increases with increasing N_2/CO_2 mixing ratio. The shape of the submicrometer particles formed in the O_2-CO_2 combustion system is spherical and similar to that formed during conventional (air) combustion, indicating that the O_2-CO_2 combustion does not affect the particle formation mechanisms. For mercury speciation, experiments were performed for coal combustion with O_2-CO_2 mixing ratios of 1:4 and 1:3, and air. The ratios of oxidized mercury to elemental mercury measured at the exit of the combustor are approximately 1:4 for the three combustion conditions.

Published Journal Articles, Completed Presentations and Students Receiving Support

Articles and Presentations:

1. Suriyawong, A., Gamble, M., Lee, M.-H., Axelbaum, R.L. and Biswas, P., "Submicron Particle Formation and Mercury Speciation under Oxygen-Carbon Dioxide Coal Combustion," Twenty-Second Annual International Pittsburgh Coal Conference, Pittsburgh, PA, Sept. 12-15, 2005.
2. Kumfer, B.M., Biswas, P. and Axelbaum, R.L., "Oxy-Combustion: Novel Strategies for Improving Combustion and Multi-Pollutant Control," Twenty-Second Annual International Pittsburgh Coal Conference, Pittsburgh, PA, Sept. 12-15, 2005.
3. Suriyawong, A., Smallwood, M., Noel, J.D., Lee, M.H., Giammar, D.E., and Biswas, P. A Strategic Approach for Optimizing the Use of Sorbents for Mercury Removal from Coal-burning Utilities. The Air and Waste Management Association's 98th Annual Conference and Exhibition, Minneapolis, MN, 2005.
4. Suriyawong, A., Lee, M.H., and Biswas P. Submicrometer Particle Formation and Mercury Emission under Enriched Oxygen Coal Combustion. Student Paper and Poster Competition, the Air and Waste Management Association's 98th Annual Conference and Exhibition, Minneapolis, MN, 2005.
5. Biswas P., and Suriyawong, A. Mercury Emissions and Transport in the Environment. Earth Day Symposium 2005, St. Louis, MO, 2005.
6. Suriyawong, A., Lee, M.H., and Biswas P.Submicrometer Particle Formation and Mercury Emission under Enriched Oxygen Coal Combustion. Earth Day Symposium 2005, St. Louis, MO, 2005.
7. Biswas, P., Suriyawong, A., Smallwood, M., Noel, J.D., Lee, M.H., Giammar, D.E., and Biswas, P. x Nanostructured-sorbents for Heavy Metals Emissions Control-A Review. American Chemical Society (ACS) 2005 Annual Conference, San Diego, CA, 2005.
8. Giammar, D.E., Noel, J.D., Smallwood, M., Suriyawong, A., Lee, M.H., and Biswas, P. Nanostructured Sorbents for Control of Mercury Emissions from Coal Combustion. The Association of Environmental Engineering and Science Professors (AEESP), Syracuse, NY, 2005.
9. Suriyawong, A.; Hogan, C. J. J.; Biswas, P., Charged Fraction and Electrostatic Capture of Ultrafine and Submicrometer Particles Formed under O2-CO2 Coal Combustion. *Environmental Science and Technology* 2006, Submitted.
10. Suriyawong, A.; Gamble, M. D.; Lee, M.; Axelbaum, R. L.; Biswas, P., Submicrometer Particle Formation and Mercury Speciation under O2-CO2 Coal Combustion. *Energy & Fuels* 2006, Submitted.

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